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CloudSat System Engineering:

Techniques That Point to a Future Success

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Topics

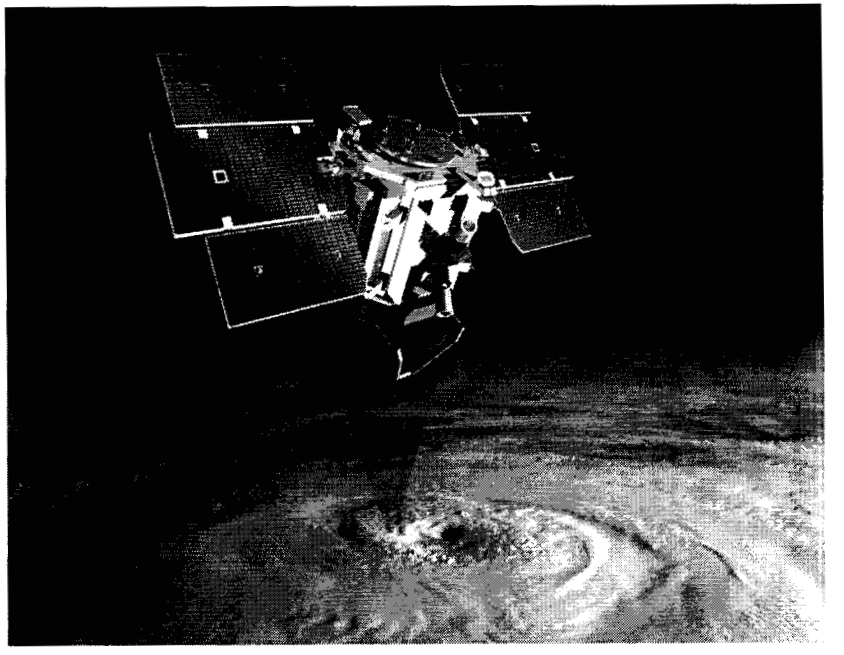
- Background & Introduction
- CloudSat Mission
- System Engineering
- Requirements
- Configuration Management
- Communications
- Responding to Change
- Summary

Background & Introduction

- CloudSat has implemented a successful system engineering approach since the mission was selected in April 1999 as an official project
- The approach was developed through
  - Examination of advertised techniques
  - Heuristic reasoning of past project performance
  - Application of professional experience
- What are some specific reasons for this success, and how can they help solve future problems?

CloudSat Mission

- NASA Earth System Science Pathfinder (ESSP) mission
- First global survey of cloud profiles and cloud properties
- First 94 GHz Cloud Profiling Radar (CPR) to operate in space
- Spacecraft will fly in formation with other cloud observing spacecraft, e.g. Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)



- Launch: April 2002 from Vandenberg Air Force Base
- Mission Duration: 22 months

System Engineering

- Defining user needs
- Defining the required functionality of the system responsive to those needs
- Overseeing/directing the technical design and development effort to assure that the resulting system will deliver those needs

➢ System engineering must direct and oversee the project's activities during the transition from one phase of development to the next

  - Has a sufficient level of maturity been reached?
  - Are all required work products completed?

System Engineering

- Extensive partnering arrangement = take maximum advantage of expertise/core competencies

ARM
Department of Energy

ESSP

Colorado State University

CIRA
Cooperative Institute for Research in the Atmosphere

JPL

Ball

CSA ASC

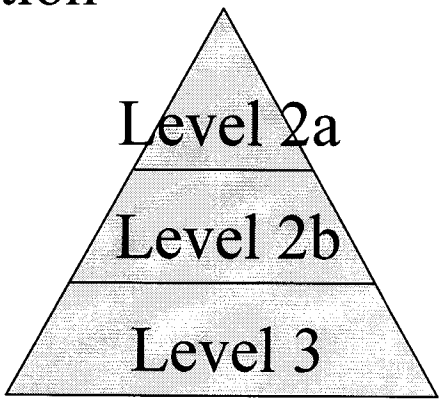
JPL

Requirements

- At project start
  - A preliminary system concept and architecture existed but no real detail about how to make this system concept work in an integrated manner
  - The engineers had only conceptual ideas about the overall designs and how their element fit in the "big picture"
  - An obvious need to develop a requirements hierarchy that flows down requirements from one level to the next
  - Ideally, the highest level requirements are defined first, then the next level, and so on…
    - Only in rare situations does this occur in a sequential manner

Requirements

- Invest early in requirements generation and analysis
  - Project personnel briefed on what would be an iterative process and the tools used - get "buy in"
  - The system engineers at all levels just started writing down the requirements
  - Many of these statements were challenged, rejected, and/or significantly modified before they are finally accepted
  - "Pit" sessions facilitated necessary interaction
  - Review conducted at task completion
  - Enabled next step, design, to be taken



Configuration Management

- Configuration management is traditionally under the purview of mission assurance at JPL
- On the CloudSat Project, it is an essential part of system engineering
- Management and control of project items, such as documents, hardware, software, and other key items are essential for managing an efficient project
- Also provides a system for evaluating and managing change
- Configuration management does not replace system engineering, but is a valuable tool

Configuration Management

- Utilize configuration management tools, but keep the number to a minimum
  - CloudSat Docushare Electronic Library - serves as the main repository for most of the documentation and records for the project. The Library houses over 3000 files for 143 users.
  - DOORS (Dynamic Object-Oriented Requirement System) - serves as the repository for all requirement documents.
  - The JPL PDMS (Product Data Management System) - serves as the repository for drawings, schematics, change records and other items such as waivers
  - The JPL UPRS (Unified Problem Reporting System) - the official repository for problem/failure and ISAs (Incident, Surprise, Anomaly) Reports.

Communications

- In any team, various types of information must be communicated between project members
- ➢ Match communication method to the criticality of the information/data and the timeliness required
- Types of information communicated from least complex to most complex

1. General Status/Issues - Verbal
2. Schedule Planning - Verbal, with written follow-up
3. Cost Planning - Verbal, with written follow-up
4. Priorities and Goals - Verbal and written
5. Requirements - Written
6. Design Detail - Written

Responding to Change

- Count on it - there will be changes
- Changes are usually driven by a better understanding of what is required, results of analyses or tests, or changing customer needs

➢ Design in flexibility and resiliency

- Conscious decisions made
  - understand the change
  - the intent of any recommendations
  - analyze the benefit
  - tailor the implementation approach all the while being sensitive to cost and schedule constraints

Responding to Change

- Example: Risk Management
  - Directive requiring the use of risk management process and risk management techniques, including fault tree analysis and probabilistic risk assessment
  - Rather than waiting for a standard to be dictated, the project chose to complete a streamlined, system-level, relative rather than absolute-based analysis and assessment
  - In the end, the analysis and assessment confirmed the robust design of the spacecraft bus, and also lead to two design changes/enhancements to the payload instrument to increase reliability

Summary

- System Engineering
  - Monitor and control phase transitions
  - Match work products to "doing" organization expertise
- Requirements
  - Invest the time and effort early to get this right
- Configuration Management (CM)
  - Utilize CM tools for effective system engineering
- Communications
  - Match methods to criticality and timeliness
- Responding to change
  - Change is inevitable - be flexible and resilient

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